The attitudes of students toward the introduction of case histories inspired from the history of science in the teaching of science

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Abstract
In this work they are presented the results of a small research concerning the attitudes of students toward the introduction of case histories, inspired from the history of science, in the teaching of science. The research concerns students aged 14-15 years who attended a teaching program about the simple pendulum. The program contains history of science material in the form of three small case histories. Data, which was collected from a questionnaire that was given to the students in the end of the teaching program, concern two teams of students. The first team attended the teaching program within a research framework related to the nature and the characteristics of the didactical transposition that takes place during an innovative teaching intervention on the simple pendulum (teacher-researcher, inquiry teaching, group observation). The second team attended the same teaching program within a framework of dissemination of the teaching program in everyday educational conditions (teacher with short-term training in the subject, regular school environment). The analysis of data shows that the big majority of students from both teams believe that the introduction of small case histories, inspired from history of science, into the teaching of the particular subject is an interesting idea and makes science comprehensive and meaningful. This interest is connected with the narrative approach in learning and understanding the world.

1. Introduction

One of the ways to introduce history of science in science education is via short stories. In this study it will be examined the introduction of short history of science stories within a teaching sequence, and the attitudes of the students towards the function of these stories in the course. The teaching sequence "*Teaching the simple pendulum*" was organized for the Greek junior high school, and includes three short texts (stories) with elements from history of science. These stories are tightly interwoven with the teaching activities, and are functional elements of the teaching sequence.

The teaching sequence was taught in two groups of students. The first group attended the teaching program in small teams within a research framework, whereas the second group attended the same teaching program within a framework of dissemination of the teaching program in everyday educational conditions. Before and after the teaching sequence was realized, students were given a questionnaire on the students' relevant knowledge. The questionnaire consisted of questions on conceptual and procedural knowledge. A second questionnaire was given to the students in the end of the teaching program, which tracked the attitudes of the students towards the short science stories and their function within the course. Data from this questionnaire consist of responses to the questions and justifications for these responses, and show that the majority of students consider that the introduction of short science stories in the teaching of the particular subject is an interesting idea that makes science meaningful and comprehensive. Data for the cognitive outcomes of the teaching sequence (from the first questionnaire) will be presented in another paper.

2. History of science in teaching

History of science has been used in teaching in many ways (Seroglou & Koumaras 2001). Some of them are the following:

a. The introduction of elements of history of science as a structural principle of curriculum (Holton 2003). In this approach the introduction of scientific concepts is based on the history of their creation, and the whole curriculum is organized around the history of these concepts. The most distinguished example for this is the *Harvard Project Physics* (1981). The program is very demanding both for teachers and students, and is considered rather impractical (Stinner et al 2003). On the other hand, as Heilbron (2002) wrote, introducing the history of science into science education, we should never miss our primary target which is teaching science and not history of science.

b. Using experiments, in the classroom or the laboratory, based on experiments carried out by scientists in the past (Seroglou, Koumaras & Tselfes 1998, Fauque 2007, Dedes & Ravanis 2009, Henke et al 2009). Traditional laboratory activities are focusing on apparatus handling and scientific (laboratory) methods and spent very little time to discuss the essential ideas and concepts inherent in the tasks. Experimental activities, on the other hand, which are based on historical experiments, can incorporate historical narratives and inspire students to move between ideas and practical activities. The intention is to guide students to manipulate ideas and concepts, not only physical objects (Metz et al 2007).

c. Using authentic or transformed historical material which is often linked to the narrative approach (Monk & Osborne 1997). Science text forms can, in general, be classified in three main categories: expository texts, argumentative texts and narrative texts (Avraamidou & Osborne 2009). Argumentative texts are mainly used in media reports of science and will not bother us here. Expository texts are usually organized according to a hierarchical pattern of main ideas and supporting details, are univocal, non-dialectic, and their focuses are descriptive or explanatory. Because they deploy the genre and grammar of the language of science, a very idiosyncratic technical language, they are difficult to understand (Taylor 1982, Avraamidou & Osborne 2009). On the other hand, narrative texts are usually organized according to a sequential pattern of events that uses the literary devices of story-telling, i.e. plot, irony, bipolar opposites etc (Taylor 1982, Metz et al 2007). Narrative is a natural way to organize our experience and knowledge and it is easy to comprehend and remember (Bruner 1996, Avraamidou & Osborne 2009). According to Millar and Osborne the use of the narratives to communicate ideas makes them coherent, memorable, and meaningful (Millar & Osborne 1998). As Metz et al (2007) have written, historical narrative is capable of providing a context to convey science content in a humanistic and authentic manner. According to Avraamidou & Osborne (2009), historical narratives of science can be used in the classroom either at the beginning of a lesson as a stimulant of interest, either as a part of an inquiry investigation, or at the end of a lesson as an application and extension of the concepts discussed. However, narratives are one of the approaches to communicate science, not the solution to all science education problems (Avraamidou & Osborne 2009).

Short stories

Science narratives can take at least two forms: stories and storylines. A story is a chronological sequence of events and actions, involving characters. A story usually contains a plot, which adds a causal or intentional element to it. Science storylines are loosely connected sets of chronological episodes taken from the history of science, related by the theme or the characters involved. These episodes could stand on their own and consist stories. Science storylines usually are employed for the study of a topic (Metz et al 2007).

An easy to handle and useful kind of science stories is the short science stories or vignettes which can convey one central idea through authentic or transformed historical material. As Stinner et al (2003) have written, telling a story is a powerful tool to engage students, and probably the best way to learn and to remember ideas. According to Ogborn et al, "stories are easy to remember because one part readily evokes the next and the need for resolution" (Ogborn et al 1996 p. 66). Moreover, short science stories are an effective way for teaching about the nature of science (Olson et al 2005). A good way to use short science stories into teaching situations is to incorporate them functionally within a teaching sequence, for example to use them in order to introduce and solve problems that would provoke students' interest (Roach 1993, Koliopoulos, Dossis & Stamoulis 2007).

Using short science stories concerns a "local" intervention in the curriculum, which can relatively easy adopted by teachers. Teachers lack knowledge both of history of science and the nature of science (Koulaidis & Ogborn 1995), and are reluctant to apply unfamiliar material that expose their weaknesses. According to Monk & Osborne, (1997) history of science will only be adopted by teachers as teaching material if it is available in a form that is brief and easy to assimilate. A carefully crafted science short story is such a material. This should be presented as a brief historical narrative, based on the ideas of a scientist, which would locate these ideas in the scientific and social context of the time (Monk & Osborne, 1997).

3. Using short texts from the history of science: the case of the teaching of simple pendulum

The teaching sequence

The teaching sequence "Teaching the simple pendulum" was organized for the students of the 9th grade of the Greek schools (14-15 years old). This concerns a total of four units referring to the teaching of the simple pendulum, and its relation to accurate timekeeping. This particular form serves the innovative as well as the inquiry approach of the science curriculum. In the traditional teaching of the pendulum, various conceptual frames are usually involved, such as Newtonian mechanics or the frame of energy conservation (Koliopoulos & Constantinou, 2005). However, in the suggested approach, there is a deep exploration of the frame of the pendulum's isochronous movement, as observed by Galileo. At the same time, there is the knowledge that, at this particular grade, the basic conceptual problem for the students is the understanding of isochronous movement as well as of the concept of the time period (Dossis & Koliopoulos, 2005). The linkage between the simple pendulum and the mechanisms of timekeeping on the one hand enhances the cultural aspect of scientific knowledge while, on the other, it gives meaning to the study of the conceptual and methodological aspect of knowledge (Koliopoulos, Dossis & Stamoulis, 2007).

The previous rationale is served by the introduction of three short texts into teaching, that includes elements from the history of science (see *Appendix 1*). The first is a simplified technical description of the first pendulum clock, focusing on the role the pendulum played in time-keeping. The second refers to an extract from Galileo's book "Dialogue Concerning Two New Sciences" and concerns the isochronous movement of the pendulum. This text is introduced into teaching in relation to the problem solving practice and aims mainly at making students discuss the paradox of the pendulum's isochronous motion. In the third text the discovery of the astronomer Jean Richer is described. According to him, the length of the pendulum for counting seconds, which was set up in Paris, should have been reduced in order for the pendulum to continue to count seconds in Cayenne (Matthews, 2000). This text is related to the formulation by the students of hypotheses on the factors on which the pendulum's time period depend. These stories are not decorative but functional elements of the teaching sequence, since they are tightly interwoven with the teaching activities. For example, they are accompanied by questions and activities (based on them) which the students have to accomplish.

We can see the general schedule of the teaching sequence in *table 1*.

Unit	**Activities / Problems**	**Type of knowledge**		
		Conceptual	**Methodological**	**Cultural**
1	**How and why the medieval pendulum-clock can become more accurate?** **CASE HISTORY 1**	- Periodicity	-The identification of factors which influence the timekeeping of pendulum-clock	- Time measurement as a techno-scientific problem
2	**Which idea is behind the function of the pendulum clock?** **CASE HISTORY 2**	- The pendulum's isochronal movement	- Measurement of period in relation to amplitude	- The historical approach of isochronal movement (Galileo)
3	**How is a simple pendulum transformed into a pendulum clock (of 1 second)?**	- Relation between period and length of string -Relation between period and mass of pendulum	- Emergence of the factors which influence period of the simple pendulum -Measurement of period in relation to length -Measurement of period in relation to mass	
4	**Is the duration of the oscillation of a simple 1 meter pendulum the same everywhere?** **CASE HISTORY 3**	- Relation between period and gravity	- Measurement of period in relation to gravity	The relation between period and gravity as socio-scientific problem

Table 1: General schedule of the teaching sequence

4. The research

The research method

The teaching sequence was taught in two groups of students (see *table 2*). The first group attended the teaching program within a research framework related to the nature and the characteristics of the didactical transposition that takes place during an innovative teaching intervention (teacher-researcher, inquiry teaching, and group observation), and occurred in very small teams of students, outside the regular classroom environment. The second group attended the same teaching program within a framework of dissemination of the teaching program in everyday educational conditions (teacher with short-term training in the subject, regular school environment).

Research group	**Implementation group**
1 teacher - researcher	3 teachers
4 schools (3 teams of 3 students in each school)	3 schools (hole classes)
36 students	63 students

Table 2: Research group and implementation group

Data were collected from a small questionnaire that was given to the students in the end of the teaching program, which tracked the attitudes of the students towards the science short stories and their function within the teaching course (see *Appendix 2*).

Results

In this paper, it will be presented only part of the analysis of data. An in depth analysis of these data is in progress.

Question 1

As you can see from the graph (*fig 1*) the great majority of the students find the short story lessons interesting.

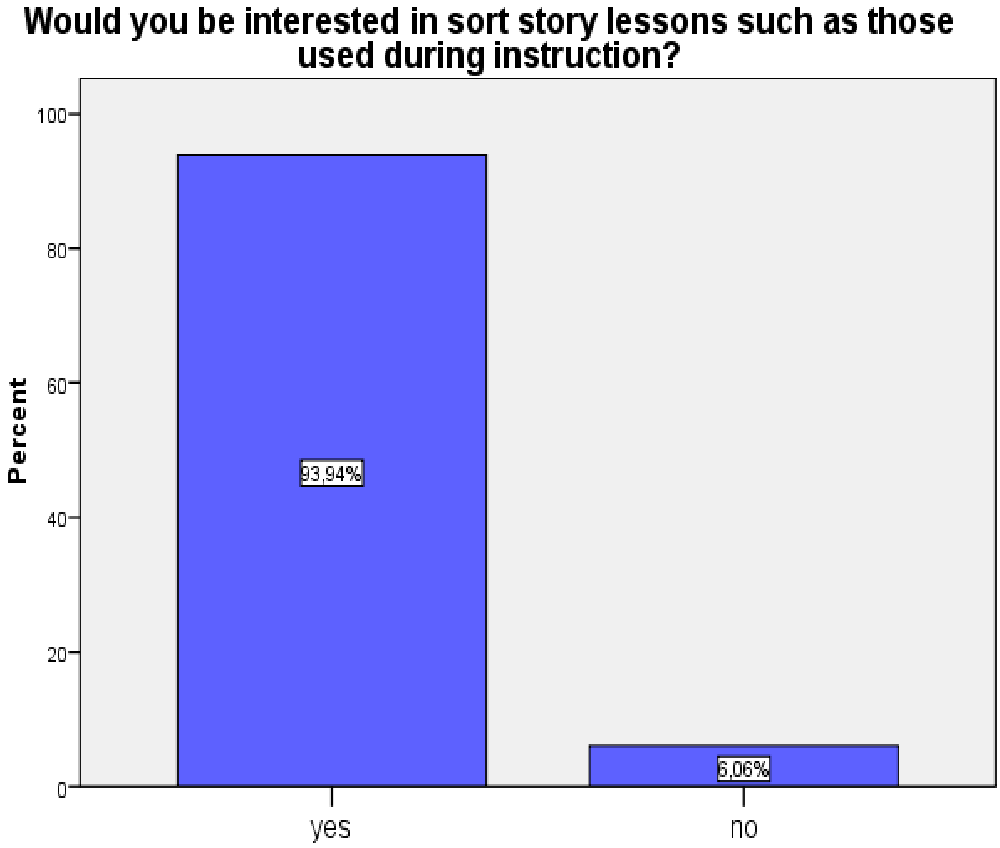

Figure 1: Responses to question 1

Justifications to question 1 were classified in four categories:
i. Emotional. A typical example of this category is: “It was more interesting and not boring”.
ii. Related to course content. For example: “We learn many things that we can not learn from the book.”
iii. Cognitive **(**related to the comprehension of the content which had been taught). For example: “The teaching becomes more comprehensible and we’ll have to read less at home.”
iv. Related to the teaching method. For example: “Stories give us material for conversation in the classroom, which I think can help us to understand theory.”

Would you be interested in short story lessons such as those used during instruction?	
Justification	**Percent on 147 justifications (99 students)**
Emotional	36.7

Teaching method	16.3
Cognitive	29.3
Course content	16.3
Other	1.4

Table 3: Justifications for question 1

As we can see from *table 3*, a relatively large number of students (36.7%) justify their responses with emotional claims, usually together with other claims. A relatively smaller number of students (29.3%) stated cognitive reasons.

Question 2

As you can see from the graph (*fig 2*), almost 50% of the students find the story of Jean Richer more interesting. This can be accounted to the fact that the story has some elements of a good narrative, that is plot, action, and unexpected events (Bruner 1996).

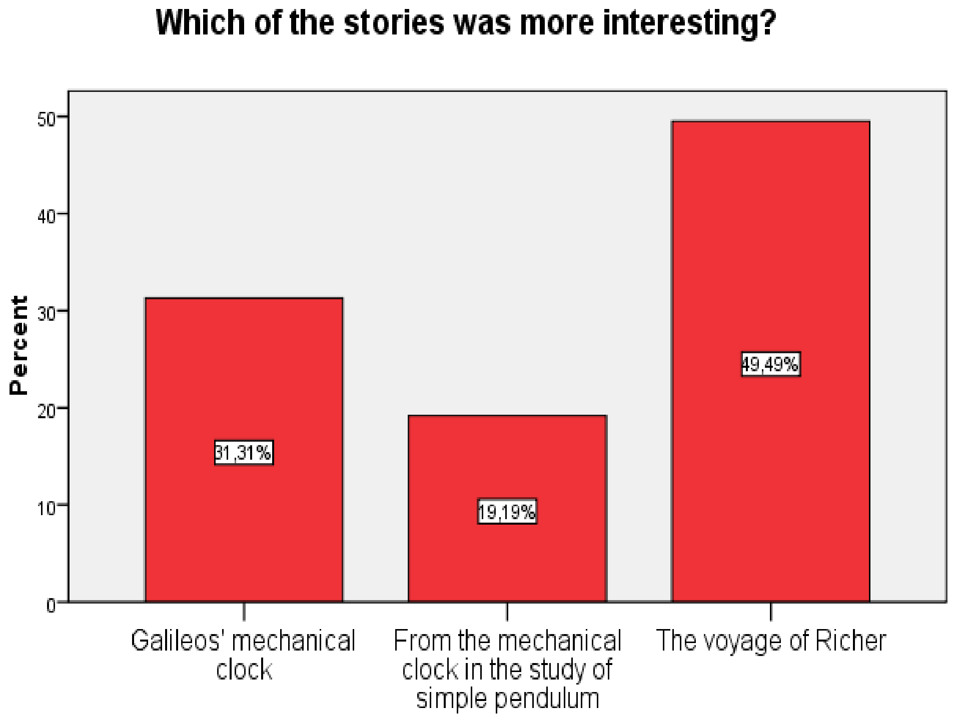

Figure 2: Responses to question 2

Justifications to question 2 were classified in four categories:
i. Emotional. For example: "Simply, I like this one more."
ii. Related to narrative approach. For example: "We have learned something by a more pleasant way. It is like a fairy tale and attracts our interest."
iii. Related to teaching (content). For example: "It put us in the process to think like Galileo and to feel like scientists who discovered something important and try to prove it to the world."
iv. Conceptual (related to the concepts which had been taught). For example: "I understood how a pendulum clock works, something that I have wondered many times."

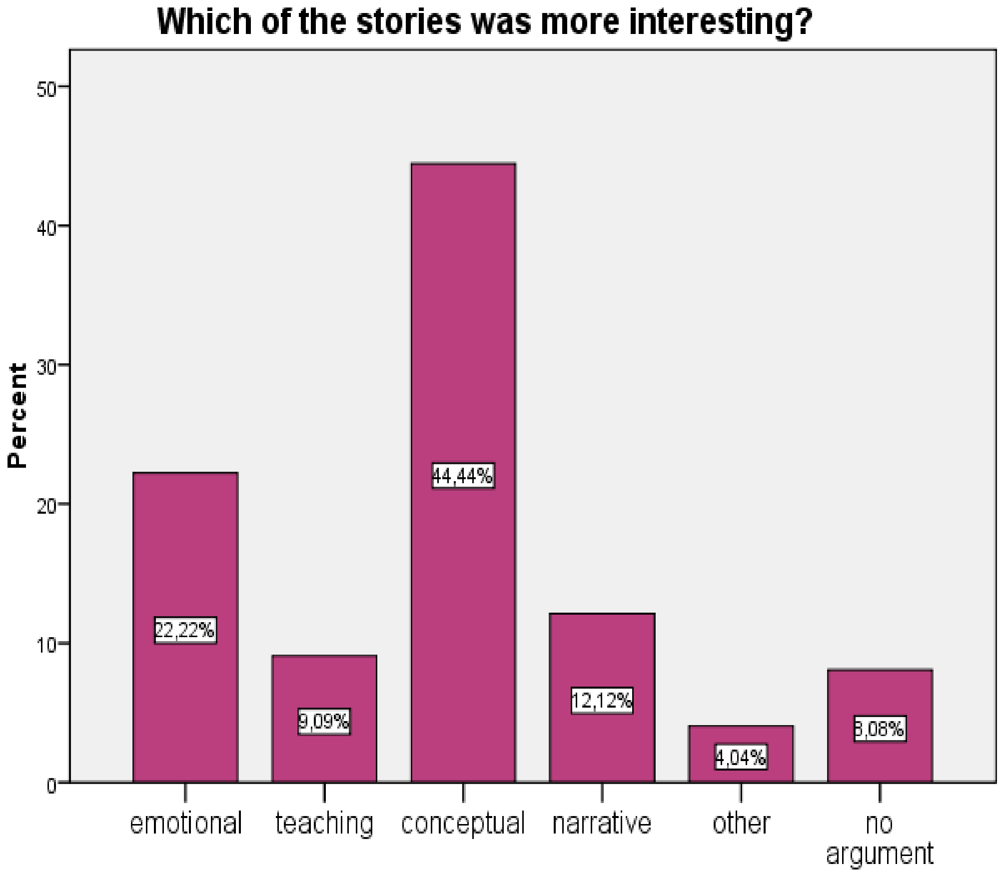

Figure 3: Justifications for question 2

The correlation between responses and justifications, which students have stated as regards the most interesting story, shows that conceptual justifications were written by students who selected the 3rd story (Richer's voyage). Typical justifications of these students are: "It seemed particularly bizarre to me that gravity plays a so important role to the clock's function, and that it can influence it" or "I couldn't imagine that a clock can be influenced by the equator".

Question 3

As you can see from the graph (*fig 4*), most students find that the story on the study of the simple pendulum is more suited to the course (physics). This can be accounted to the fact, as some of the students mention, that it refers to pendulums, times of oscillation, and experiments; ordinary objects of physics lessons.

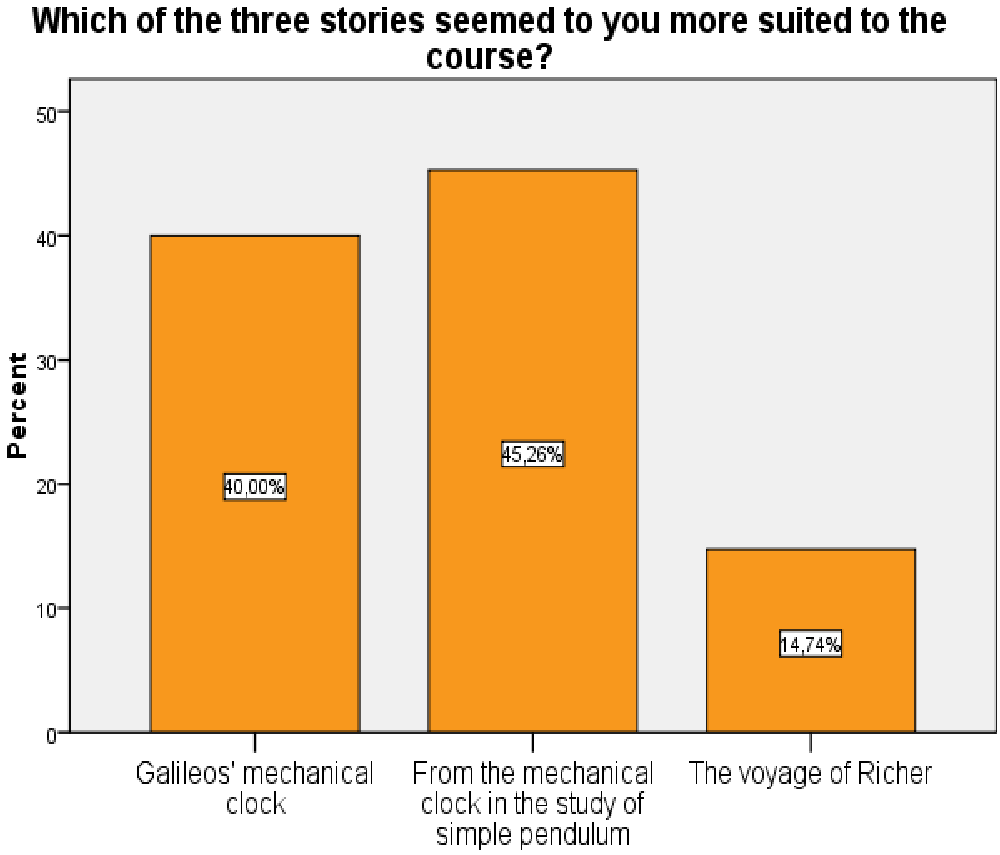

Figure 4: Responses to question 3

Justifications to question 3 were classified in four categories:
i. Emotional. For example: “This course was more interesting and I was excited.”
ii. Fit to nature of the course. For example: “It was more closely related to the course’s subject matter, because we could examine the properties of the simple pendulum and what things influence it.”
iii. Related to the expansion of knowledge. For example: “Because we have learned how the clock works, and how to correct a clock which goes wrong.”
iv. Related to the nature of the course. For example: “Because when we say physics, we all have in mind formulas, pendulums and oscillations.”

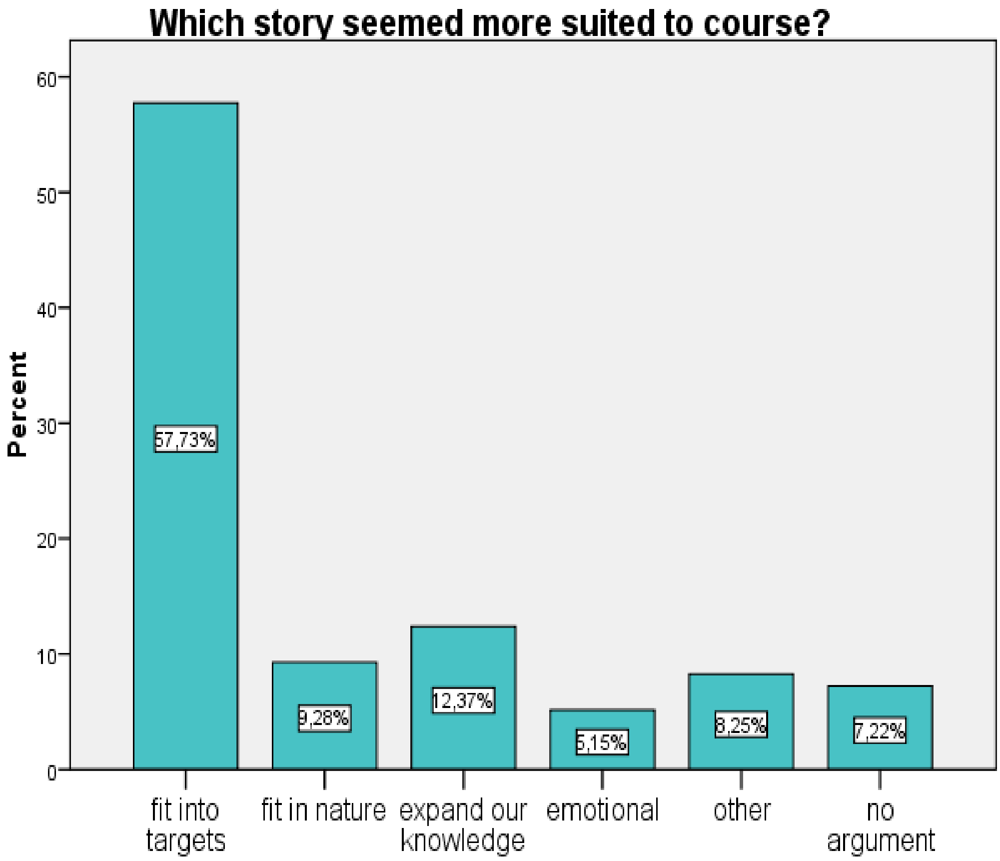

Figure 5: Justifications for question 3

The correlation between responses and justifications, which students have stated as regards the story most suited to the teaching course, shows that students who selected the 2nd story (study of the simple pendulum) believe that this story fits more to the aims of the course (physics). Typical justifications of these students are: “It was more closely related to the course’s subject matter, because we could examine the properties of the simple pendulum and what things influence it” or “It fits to the course more, because we have studied the simple pendulum”.

Question 4

As you can see from the graph (*fig 6*), the vast majority of students do not bother from the fact that the stories are about the past.

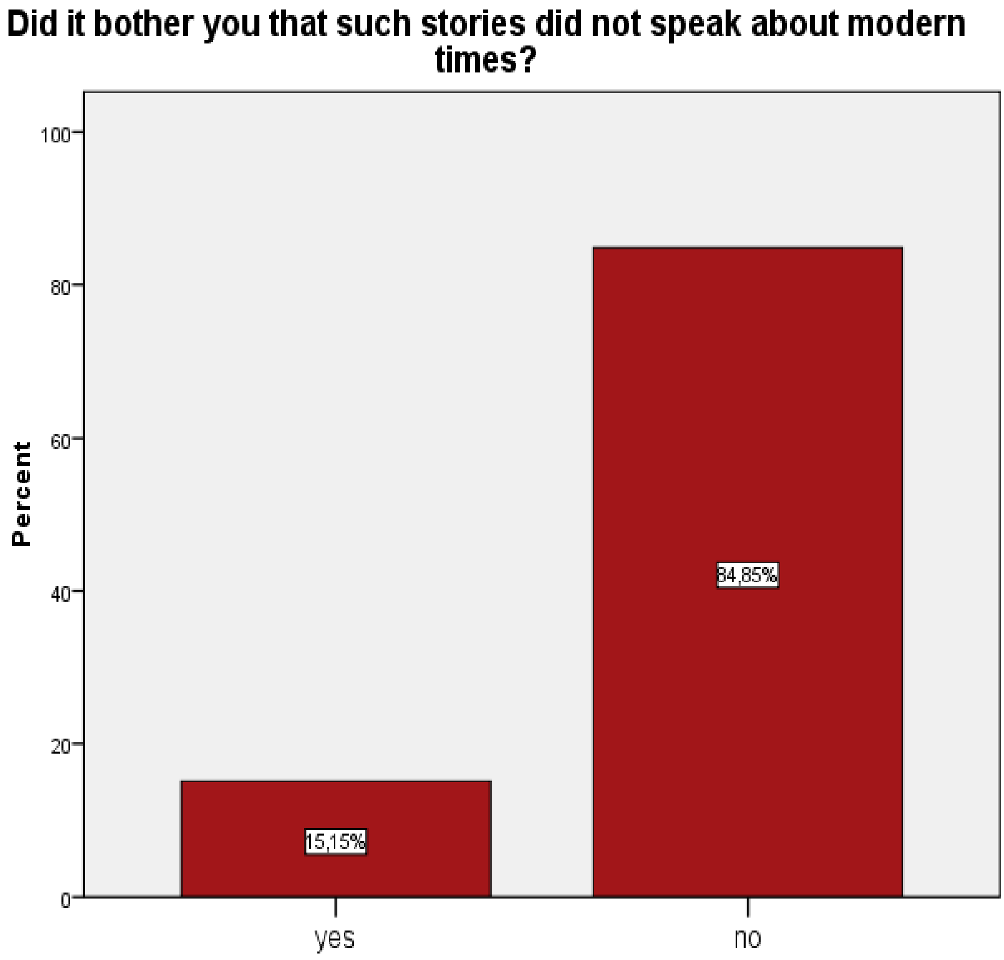

Figure 6: Responses to question 4

Justifications to question 4 were classified in four categories:
i. Related to comprehension. For example: "It is much better to learn and to read from the beginning, from the old times, from the time the historical character begun to work with this phenomenon."
ii. Emotional. For example: "The past, which we don't know, is much more amusing and interesting."
iii. Related to old era – people. For example: "It was great to learn how all that we know today in physics was made. The way they managed to make such discoveries without the help of technology was exciting."
iv. Comparison with current knowledge. For example: "I believe that all important things that were done in physics, were done in the old times."

Justification	**Percent**
Related to comprehension	14.1%

Emotional	9.1%
Related to old era/people	37.4%
Comparison with current knowledge	20.2%
Other argument	12.1%
No argument	7.1%

Table 4: Justifications to question 4

As we can see in *table 4*, as most prevalent justifications for not bothering for the historical character of the stories, students have stated that they are interested on the old times and that they can compare nowadays knowledge with the old knowledge. A typical justification of the first kind is : "We have learned some things for the techniques which people used in these times". A typical justification of the second kind is: "I believe that all important things that were done in physics, were done in the old times".

The most interesting story in relation to gender

The most interesting story - gender		
	Male (45)	**Female (54)**
Galileo's mechanical clock	42.2%	22.2%
From the mechanical clock to the study of simple pendulum	11.1%	25.9%
The voyage of Jean Richer	46.7%	51.9%
Total	100%	100%

Table 5: The most interesting story in relation to gender

As we can see in *table 5*, both males and females find interesting the 3rd story (Richer's voyage). As regards the other two stories, however, their selection is significantly different. Males select the 1st story (mechanical clock), whereas females select the 2nd (study of simple pendulum). The technical character of the 1st story could be an explanation of the boys' preference. A typical justification of a boy who selected the 1st story as more interesting is: "I have learned exactly how the everyday clock was created and how it is functioning, counting seconds". A typical justification of a girl who selected the 2nd story as more interesting is: "I like it more because it puts you to think, to create interpretations, and to draw conclusions".

The story most suited to course in relation to gender

The story most suited to course - gender		
	Male (43)	**Female (52)**
Galileo's mechanical clock	46.5%	34.6%
From the mechanical clock to the study of simple pendulum	41.9%	48.1%
The voyage of Jean Richer	11.6%	17.3%
Total	100%	100%

Table 6: The story most suited to course in relation to gender

As we can see in *table 6*, males' and females' selections for the story most suited to course are not very different. Although their first selection is a little different, for both genders the 3rd story is not in fact a choice.

The most interesting story in relation to student's group

The most interesting story - student's group		
	Research group	**Implementation group**

Galileo's mechanical clock	25.0%	34.9%
From the mechanical clock to the study of simple pendulum	22.2%	17.5%
The voyage of Jean Richer	52.8%	47.6%
Total	100%	100%

Table 7: The most interesting story in relation to student's group

As we can see in *table 7*, research group's and implementation group's selections for the most interesting story are not much different. Both groups find more interesting the 3rd story.

The story most suited to course in relation to student's group

The story most suited to course - student's group		
	Research group	**Implementation group**
Galileo's mechanical clock	60.0%	28.3%
From the mechanical clock to the study of the simple pendulum	34.3%	51.7%
The voyage of Jean Richer	5.7%	20.0%
Total	100%	100%

Table 8: The story most suited in relation to student's group

As we can see in *table 8*, the selection of the story most suited to course seems to depend on the student's group. 60% of the research group select the 1st story (mechanical clock), whereas 51.7% of the implementation group select the 2nd story (study of the simple pendulum). A possible explanation could be that the research group refers mainly to the certain teaching sequence, whereas the implementation group refers to physics lessons in general. A typical justification of a student from the research group who selected the 1st story is: “The lesson refers to the simple pendulum, but in order to move on we have to learn about the mechanical clock”. A typical justification of a student from the implementation group who selected the 2nd story is: “It was more closely related to the course’s subject matter, because we could examine the properties of the simple pendulum and what things influence it”.

5. Discussion

Introducing elements of history of science via short stories into a teaching sequence of physics seems to offer multiple benefits, mainly cognitive and motivational. The cognitive outcomes of the teaching sequence will be presented in another paper. As regards the attitudes of the students towards the short science stories and the stories’ function in the teaching course, it appears that:

i. The big majority of students consider that the introduction of short stories into teaching, inspired from the history of science, is an interesting idea that makes science comprehensible and meaningful.

ii. Students select, as the most interesting story, the story which has more elements of a good narrative: plot, action, and unexpected events (3rd story - Richer’s voyage).

iii. Students do not bother that the stories do not refer to modern times but to the past.

iv. There are many similarities and some differences between the two genders. For example, both males and females consider the 3rd story (Richer’s voyage) as the most interesting story but the least suited to the teaching course. On the other hand, the second more prevalent selection of the most interesting story is different. Males seem to select the story with a technical character (1st story – mechanical clock), while females seem to select the story with more school science characteristics (2nd story – study of the pendulum).

v. The two groups of students (research group and implementation group) seem to differentiate on what story suits to teaching course more. The research group selects the story with more cultural and context of science characteristics (1st story – mechanical clock), whereas the implementation group selects the story with more school science characteristics (2nd story – study of the pendulum). The difference might be due to the different settings of the teaching. The implementations group’s teaching occurred within the regular physics course, in the regular classroom environment, whereas the research group’s teaching occurred in very small teams of students, outside the regular classroom environment, in the climate of an innovative teaching intervention.

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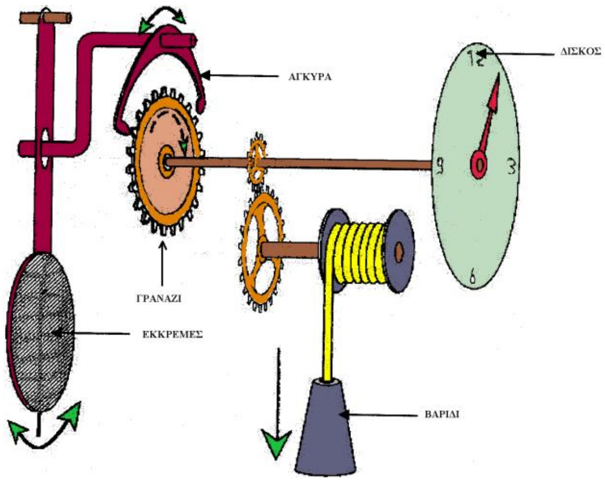
APPENDIX 1

The short stories

***Case history 1**: Galileo's mechanical clock*



The year 1636, Galileo proposes to the Dutch the construction of a clock mechanism (see pictures) as which he claims “If you leave 4 or 6 of them to work simultaneously, you will not find differences in either of them not in 1 second or even after several months”. A figure representation of this clock - pendulum is shown below. The mechanical pendulum consists of four main parts: (a) of the pendulum which is swung (b) of the anchor that is attached to the pendulum, so the swing of the pendulum be followed by a back and forth movement of the anchor (c) of a weight, which its fall causes the movement of the gears and the rod that is connected to the clock Indicators and (d) of the disk on which are the indications of time and the indicators rotate. The anchor and gear (called escape mechanism) convert the continuous rotation of the gear in back and forth movement of the anchor When the pendulum is at a extreme position, the "tooth" of the anchor locks the gear and does not let it spin. When the pendulum is hanging in the centre of the movement, the anchor releases the gear so it rotates, for a short time. When the pendulum reaches the opposite extreme position, the other "tooth" of the anchor "relocks" the gear and stops the rotation violently. The beat of conflict between the "tooth" of the anchor and the "tooth" of the gear is the familiar "tick-tack" of clocks. At the same time the gear, because of the weight, pushes back the anchor and the pendulum and the process repeats itself.

Questions and activities

a. Discuss the text with your teacher trying to understand how the clock works. What is the role of the four key elements of a pendulum clock?

- *Pendulum*
- *Anchor -gear (escape mechanism)*
- *Weight that falls*
- *Disk with clock indicators*

b. Assuming that the pendulum clock goes forward, what changes would you suggest to regulate it? Justify your opinion.

***Case history 2**: From mechanical clock to pendulum study*

The year 1638 was a historic one for science. *Galileo* published his work *Dialogues Concerning Two New Sciences*, one of the first written records of the birth of modern Physics. Galileo wrote *Dialogue*s in the form of a play and discusses his ideas through its three main characters: *Salviati*, a brilliant scientist, who expresses Galileo's beliefs, *Sagredo*, a clever amateur disguised as a neutral participant and *Simplicio*, the well-meaning defender of the ideas of the time. The following excerpt from Galileo's *Dialogues Concerning Two New Sciences* deals with pendulum motion.

"*Sagredo*: … I have observed, thousands of times, the swinging of chandeliers, especially in churches, or lamps hanging from the ceiling and moving to and fro. But the only thing I have established from these observations is that it is most unlikely that the opinion of those people who claim that all these oscillations are maintained by the environment is correct. For, if that were the case, then the wind would have to act with great insight and have nothing else to do than to give this suspended weight a perfectly regular to-and-fro motion. It is impossible for me to imagine that the same body, suspended from a string of approximately 50 meters, and moved away by 90 degrees (90^o) from its perpendicular position and then one degree (1^o) from the perpendicular position could, in both cases, take the same time to cover a very large arc and then next a very small one. That seems to me very unlikely." (Adopted from Galileo 1978 p.172).

Questions and activities

a. How do you think that Salviati (the person expressing Galileo's views) would respond to the views of Sagredo?

b. Which particular technique would you suggest in order to examine whether Sagredo's claim is true or false?

Case history 3: An exciting discovery: the voyage of Jean Richer to Cayenne

In 1672, the astronomer *Jean Richer*, was sent on a scientific mission by the French Academy of Sciences to the city of *Cayenne*, which is in French Guyana near the equator. Richer had a pendulum clock with him (like the one you seem in the photograph) which had been set in *Paris* to oscillate in periods of 1 second. On observing the pendulum in Cayenne, Richer made an unexpected discovery: *The pendulum clock was slow by 2.5 min each day*.

Richer's claim that the pendulum clock of 1 sec slows down near the equator triggered a very interesting discussion concerning why this occurs. Some scientists doubted his measurements. In fact, there were several arguments like the one between Richer and Huygens, the man who had constructed the clock Richer had with him.

Others tried to interpret the results of these measurements. They claimed that the assumption that the period of the pendulum depends only on the length of the string is not valid. In this way, they tried to identify other factors which could influence the period. This was in fact proven to be correct! (Mathews 2000).

Questions and activities

a. Which in your opinion is the factor which influenced the results of the measurements kept by Richer in Cayenne?

b. In which ways could someone confirm or discredit the idea that period depends on gravity? (Specifically, the grater the gravity is the smaller the period becomes)?

c. How could this problem be resolved, in those times?

APPENDIX 2

Questionnaire

1. Would you be interested in short story lessons such as those used during instruction? Justify your answer.
2. Which of the three short stories seemed more interesting? Justify your answer.
3. Which of the three short stories seemed to you more suited to the teaching course? Justify your answer.
4. The three short stories used in class refer to earlier times in history and historical figures who played an important role in the development of physics. Did it bother you that such stories did not speak about modern times? Justify your answer.